Claims

1. A power supply system comprising:

a. a hydrogen storage module;

b. a fuel cell power module coupled to said hydrogen storage module, said fuel cell power module comprising at least one fuel cell having an anode and a cathode;

c. an electrolyzer module coupled to said hydrogen storage module, said electrolyzer module comprising at least one electrolyzer cell having an anode and a cathode; and

d. a control module coupled to said hydrogen storage, fuel cell power, and electrolyzer modules;

wherein said system is operable in at least a hydrogen generation mode where hydrogen gas is generated by said at least one electrolyzer cell received thereby for storage in said hydrogen storage module, and an electricity generation mode where hydrogen gas is retrieved from said hydrogen storage module and used by said at least one fuel cell unit to produce electric energy.

2. The system of claim 1, wherein said electrolyzer module comprises at least one temperature regulation device coupled to said at least one electrolyzer cell for varying the operating temperature of said at least one electrolyzer cell, such that the current draw of said at least one electrolyzer cell is controlled.

3. The system of claim 2, wherein said at least one temperature regulation device comprises a heat exchanger for varying the temperature of water entering said at least one electrolyzer cell.

4. The system of claim 2, wherein said at least one electrolyzer cell operates at a substantially constant operating voltage while said operating temperature thereof is varied, and wherein said operating temperature thereof is varied by said at least one temperature regulation device such that variations in said current draw is a function of variations in said operating temperature.

5. The system of claim 2, wherein said at least one electrolyzer cell operates at a varying operating voltage while said operating temperature is varied, and wherein said operating temperature thereof is varied by said at least one temperature regulation device such that said current draw is maintained substantially constant.

6. The system of claim 1, wherein said electrolyzer module comprises a pressure regulating device coupled to one of the anode and cathode of said at least one electrolyzer cell, wherein gas at the other of the anode and cathode of said at least one electrolyzer cell is used to control the operation of said pressure regulating device, such that a substantially constant differential pressure between said anode and cathode of said at least one electrolyzer cell is maintained.

7. The system of claim 6, wherein said pressure regulating device is a mechanical regulating valve.

8. The system of claim 7, wherein said pressure regulating device is a dome loading pressure regulating valve.

9. The system of claim 8, wherein said pressure regulating device is a dome loading back pressure regulating valve.

10. The system of claim 9, wherein said pressure regulating device comprises an inlet for receiving gas from the anode of said at least one electrolyzer cell, wherein said pressure regulating device receives a dome load signal from the cathode of said at least one electrolyzer cell, and wherein in operation, said pressure regulating device opens to allow gas to flow from said inlet to an outlet of said pressure regulating device when the pressure at said inlet exceeds the pressure of said dome load signal.

11. The system of claim 9, wherein said pressure regulating device comprises an inlet for receiving gas from the cathode of said at least one electrolyzer cell, wherein said pressure regulating device receives a dome load signal from the anode of said at least one electrolyzer cell, and wherein in operation, said pressure regulating device opens to allow gas to flow from said inlet to an outlet of said pressure regulating device when the pressure at said inlet exceeds the pressure of said dome load signal.

12. The system of claim 1, wherein said electrolyzer module comprises a drying unit coupled to the cathode of said at least one electrolyzer cell, and wherein said electrolyzer module further comprises a pressure regulating device coupled between said cathode and said drying unit, such that pressure fluctuations of said drying unit are isolated from said cathode.

13. The system of claim 12, wherein said electrolyzer module further comprises an additional pressure regulating device coupled between said drying unit and said hydrogen storage module, such that pressure

fluctuations of said drying unit are also isolated from said hydrogen storage module.

14. The system of claim 1, wherein said electrolyzer module comprises a pump adapted to provide water to said at least one electrolyzer cell at a flow rate and at sufficiently low pressure so that a determined differential pressure limit is not exceeded, and wherein in operation, water is supplied to said at least one electrolyzer cell in said hydrogen generation mode by said pump at a rate associated with a desired rate of hydrogen production by said electrolyzer module.

15. The system of claim 14, wherein said pump is a centrifugal pump.

16. The system of claim 1, wherein said fuel cell power module comprises at least one oxidant supplying device to supply an oxygen-containing gas to said at least one fuel cell, such that the rate at which said oxygen-containing gas is supplied by said at least one oxidant supplying device is a function of at least the current draw on said at least one fuel cell during operation of said at least one fuel cell in said electricity generation mode.

17. The system of claim 16, wherein said at least one oxidant supplying device comprises one or more air blowers.

18. The system of claim 16, wherein the rate at which said oxygen-containing gas is supplied by said at least one oxidant supplying device is also a function of stoichiometric data predetermined for said system.

19. The system of claim 16, wherein said fuel cell power module further comprises a voltage monitoring device coupled to said at least one fuel

cell, wherein the rate at which said oxidant-containing gas is supplied by said at least one oxidant supplying device is also dependent on measurements obtained by said voltage monitoring device.

20. The system of claim 1, wherein said fuel cell power module comprises a pressure regulating device coupled to one of the anode and cathode of said at least one fuel cell, wherein gas at the other of the anode and cathode of said at least one fuel cell is used to control the operation of said pressure regulating device, such that a substantially constant differential pressure between said anode and cathode of said at least one fuel cell is maintained.

21. The system of claim 20, wherein said pressure regulating device is a mechanical regulating valve.

22. The system of claim 21, wherein said pressure regulating device is a bias dome loading pressure regulating valve.

23. The system of claim 20, wherein said pressure regulating device is a forward pressure regulating valve.

24. The system of claim 23, wherein said pressure regulating device is a dome loading forward pressure regulating valve.

25. The system of claim 24, wherein said pressure regulating device is a bias dome loading forward pressure regulating valve that comprises an inlet for receiving gas from a hydrogen supply and an outlet to provide hydrogen to the anode of said at least one fuel cell, wherein said pressure regulating device receives a dome load signal from the cathode of said at least one

fuel cell, and wherein in operation, said pressure regulating device opens to allow gas to flow from said inlet to said outlet of said pressure regulating device when the pressure at said outlet drops below a biased pressure value, said biased pressure value being the sum of the pressure of said dome load signal and a bias setting value.

26. The system of claim 1, wherein said electrolyzer module comprises a determined number of electrolyzer cells having an active area such that said at least one electrolyzer cell can be directly connected to a power source of said vehicle to receive power from said power source in hydrogen generation mode, and wherein said fuel cell power module comprises a determined number of fuel cells having an active area such that said at least one fuel cell can be directly connected to supply power to said vehicle in electricity generation mode.

27. The system of claim 1, wherein said hydrogen storage module comprises a storage unit of one or more cylinders, each containing metal hydrides, for storing hydrogen generated by said at least one electrolyzer cell; and wherein said hydrogen storage module further comprises a water circulation system coupled to said storage unit and said at least one fuel cell, wherein water is circulated in said water circulation system in at least one of said hydrogen generation and electricity generation modes.

28. The system of claim 27, wherein waste heat generated by said at least one fuel cell is transferred to said water in said electricity generation mode, to enhance desorption of hydrogen in said hydrogen storage module.

29. The system of claim 27, wherein said storage unit is sized such that the waste heat generated by said at least one fuel cell is sufficient to desorb hydrogen at a specified rate of hydrogen flow.

30. The system of claim 27, wherein heat generated by said hydrogen storage module in said hydrogen generation mode is transferred to said water, to preheat said at least one fuel cell.

31. The system of claim 30, wherein said water circulation system comprises a water jacket through which water may circulate, wherein said water jacket surrounds at least a part of said storage unit, to facilitate transfers of heat between said storage unit and said water.

32. The system of claim 30, wherein said water circulation system comprises an internal cooling loop within said storage unit through which water may circulate, to facilitate transfers of heat between said storage unit and said water.

33. An electrolyzer module comprising:

a. at least one electrolyzer cell, said at least one electrolyzer cell having an anode and a cathode;
b. a water supply for supplying water to said at least one electrolyzer cell;
c. a power supply for supplying power to said at least one electrolyzer cell;
d. one or more connections for coupling said at least one electrolyzer cell to a hydrogen storage module; and

e. at least one temperature regulation device coupled to said at least one electrolyzer cell for varying the operating temperature of said at least one electrolyzer cell, such that the current draw of said at least one electrolyzer cell is controlled.

34. The electrolyzer module of claim 33, wherein said at least one temperature regulation device comprises a heat exchanger for varying the temperature of water entering said at least one electrolyzer cell.

35. The electrolyzer module of claim 33, wherein said at least one electrolyzer cell operates at a substantially constant operating voltage while said operating temperature thereof is varied, and wherein said operating temperature thereof is varied by said at least one temperature regulation device such that variations in said current draw is a function of variations in said operating temperature.

36. The electrolyzer module of claim 33, wherein said at least one electrolyzer cell operates at a varying operating voltage while said operating temperature is varied, and wherein said operating temperature thereof is varied by said at least one temperature regulation device such that said current draw is maintained substantially constant.

37. An electrolyzer module comprising:

a. at least one electrolyzer cell, said at least one electrolyzer cell having an anode and a cathode;
b. a water supply for supplying water to said at least one electrolyzer cell;

c. a power supply for supplying power to said at least one electrolyzer cell;

d. one or more connections for coupling said at least one electrolyzer cell to a hydrogen storage module; and

e. a pressure regulating device coupled to one of the anode and cathode of said at least one electrolyzer cell, wherein gas at the other of the anode and cathode of said at least one electrolyzer cell is used to control the operation of said pressure regulating device, such that a substantially constant differential pressure between said anode and cathode of said at least one electrolyzer cell is maintained.

38. The electrolyzer module of claim 37, wherein said pressure regulating device is a mechanical regulating valve.

39. The electrolyzer module of claim 38, wherein said pressure regulating device is a dome loading pressure regulating valve.

40. The electrolyzer module of claim 39, wherein said pressure regulating device is a dome loading back pressure regulating valve.

41. The electrolyzer module of claim 40, wherein said pressure regulating device comprises an inlet for receiving gas from the anode of said at least one electrolyzer cell, wherein said pressure regulating device receives a dome load signal from the cathode of said at least one electrolyzer cell, and wherein in operation, said pressure regulating device opens to allow gas to flow from said inlet to an outlet of said pressure regulating device when the pressure at said inlet exceeds the pressure of said dome load signal.

42. The electrolyzer module of claim 40, wherein said pressure regulating device comprises an inlet for receiving gas from the cathode of said at least one electrolyzer cell, wherein said pressure regulating device receives a dome load signal from the anode of said at least one electrolyzer cell, and wherein in operation, said pressure regulating device opens to allow gas to flow from said inlet to an outlet of said pressure regulating device when the pressure at said inlet exceeds the pressure of said dome load signal.

43. An electrolyzer module comprising:

a. at least one electrolyzer cell, said at least one electrolyzer cell having an anode and a cathode;
b. a water supply for supplying water to said at least one electrolyzer cell;
c. a power supply for supplying power to said at least one electrolyzer cell;
d. one or more connections for coupling said at least one electrolyzer cell to a hydrogen storage module;
e. a drying unit coupled to the cathode of said at least one electrolyzer cell; and
f. a pressure regulating device coupled between said cathode and said drying unit, such that pressure fluctuations of said drying unit are isolated from said cathode.

44. The electrolyzer module of claim 43, further comprising an additional pressure regulating device coupled between said drying unit and said

hydrogen storage module, such that pressure fluctuations of said drying unit are also isolated from said hydrogen storage module.

45. An electrolyzer module comprising:

a. at least one electrolyzer cell, said at least one electrolyzer cell having an anode and a cathode;
b. a water supply for supplying water to said at least one electrolyzer cell;
c. a power supply for supplying power to said at least one electrolyzer cell;
d. one or more connections for coupling said at least one electrolyzer cell to a hydrogen storage module; and
e. at least one pump adapted to provide water to said at least one electrolyzer cell at a flow rate and at sufficiently low pressure so that a determined differential pressure limit is not exceeded, wherein in operation, water is supplied to said at least one electrolyzer cell by said pump at a rate associated with a desired rate of hydrogen production by said electrolyzer module.

46. The electrolyzer module of claim 45, wherein said at least one pump comprises a centrifugal pump.

47. A fuel cell power module comprising:

a. at least one fuel cell, said at least one fuel cell having an anode and a cathode;
b. one or more first connections for coupling said at least one fuel cell to a hydrogen storage module containing hydrogen;

c. one or more second connections for coupling said at least one fuel cell to a load to be driven by said at least one fuel cell; and
d. an oxidant supplying device for supplying oxygen-containing gas to said at least one fuel cell, wherein said oxidant supplying device supplies oxygen-containing gas to said at least one fuel cell at a rate that is a function of at least the current draw on said at least one fuel cell during operation of said at least one fuel cell.

48. The fuel cell power module of claim 47, wherein said at least one oxidant supplying device comprises one or more air blowers.

49. The fuel cell power module of claim 47, wherein the rate at which said oxygen-containing gas is supplied by said at least one oxidant supplying device is also a function of predetermined stoichiometric data.

50. The fuel cell power module of claim 47, further comprising a voltage monitoring device coupled to said at least one fuel cell, wherein the rate at which said oxygen-containing gas is supplied by said at least one oxidant supplying device is also dependent on measurements obtained by said voltage monitoring device.

51. A fuel cell power module comprising:

a. at least one fuel cell, said at least one fuel cell having an anode and a cathode;
b. one or more first connections for coupling said at least one fuel cell to a hydrogen storage module containing hydrogen;
c. one or more second connections for coupling said at least one fuel cell to a load to be driven by said at least one fuel cell;

d. an oxidant supplying device for supplying oxygen-containing gas to said at least one fuel cell; and

e. a pressure regulating device coupled to one of the anode and cathode of said at least one fuel cell, wherein gas at the other of the anode and cathode of said at least one fuel cell is used to control the operation of said pressure regulating device, such that a substantially constant differential pressure between said anode and cathode of said at least one fuel cell is maintained.

52. The fuel cell power module of claim 51, wherein said pressure regulating device is a mechanical regulating valve.

53. The fuel cell power module of claim 52, wherein said pressure regulating device is a bias dome loading pressure regulating valve.

54. The fuel cell power module of claim 51, wherein said pressure regulating device is a forward pressure regulating valve.

55. The fuel cell power module of claim 54, wherein said pressure regulating device is a dome loading forward pressure regulating valve.

56. The fuel cell power module of claim 55, wherein said pressure regulating device is a bias dome loading forward pressure regulating valve that comprises an inlet for receiving gas from said hydrogen storage module and an outlet to provide hydrogen to the anode of said at least one fuel cell, wherein said pressure regulating device receives a dome load signal from the cathode of said at least one fuel cell, and wherein in operation, said pressure regulating device opens to allow gas to flow from said inlet to said outlet of said pressure regulating device when the pressure at said

outlet drops below a biased pressure value, said biased pressure value being the sum of the pressure of said dome load signal and a bias setting value.

57. A hydrogen storage module for coupling to a fuel cell power module, said hydrogen storage module comprising:

a. a storage unit of one or more cylinders, each containing metal hydrides, for storing hydrogen; and

b. a water circulation system coupled to said storage unit and said at least one fuel cell, wherein water is circulated in said water circulation system.

58. The hydrogen storage module of claim 57, wherein in operation of said fuel cell power module, waste heat generated by at least one fuel cell of said fuel cell power module is transferred to said water, to enhance desorption of hydrogen in said hydrogen storage module.

59. The hydrogen storage module of claim 58, wherein said storage unit is sized such that the waste heat generated by said at least one fuel cell is sufficient to desorb hydrogen at a specified rate of hydrogen flow.

60. The hydrogen storage module of claim 57, wherein heat generated by said hydrogen storage module when said hydrogen storage module is being filled is transferred to said water, to preheat said at least one fuel cell.

61. The hydrogen storage module of claim 57, wherein said water circulation system comprises a water jacket through which water may circulate,

wherein said water jacket surrounds at least a part of said storage unit, to facilitate transfers of heat between said storage unit and said water.

62. The hydrogen storage module of claim 57, wherein said water circulation system comprises an internal cooling loop within said storage unit through which water may circulate, to facilitate transfers of heat between said storage unit and said water.

63. An electrolyzer module for use in a vehicle comprising:

a. at least one electrolyzer cell, said at least one electrolyzer cell having an anode and a cathode;
b. a water supply for supplying water to said at least one electrolyzer cell;
c. a power supply for supplying power to said at least one electrolyzer cell; and
d. one or more connections for coupling said at least one electrolyzer cell to a hydrogen storage module;

wherein said electrolyzer module comprises a determined number of electrolyzer cells having an active area such that said at least one electrolyzer cell can be directly connected to a power source of a vehicle to receive power from said power source.

64. A fuel cell power module for use in a vehicle comprising:

a. at least one fuel cell, said at least one fuel cell having an anode and a cathode;
b. one or more first connections for coupling said at least one fuel cell to a hydrogen storage module containing hydrogen;

c. one or more second connections for coupling said at least one fuel cell to a load to be driven by said at least one fuel cell; and

d. an oxidant supplying device for supplying oxygen-containing gas to said at least one fuel cell;

wherein said fuel cell power module comprises a determined number of fuel cells having an active area such that said at least one fuel cell can be directly connected to supply power to said vehicle.